Paleoseismology Study in the Cache River Valley, Southern Illinois

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Annual Project Summary

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Investigations Undertaken

This paleoseismology investigation of the Cache River Valley (CRV) of southern Illinois is a collaboration between J. Chester (TAMU) and M. Tuttle (M. Tuttle & Associates) with contributions by E. Schweig (USGS), J. Sims (John Sims and Associates; formerly of USGS) and B. Noonan (M.S. student at TAMU). The CRV is located along the northern margin of the Mississippi embayment, immediately northeast of the New Madrid seismic zone and southwest of the Wabash Valley seismic zone. Small to moderate earthquakes are common in this region, though less frequent than in the surrounding seismic zones. The CRV is located between several major fault systems including the Fluorospar Area fault complex to the east, Commerce fault system to the west, and Ste. Genevieve/Iron Mountain fault system to the northwest. Some significant post-Cretaceous faulting has occurred in these regions (e.g., Harrison and Schultz, 1994; Nelson, 1995, Nelson et al., 1997; Hoffman et al., 1996). During prior reconnaissance in the region, we found earthquake-induced liquefaction features including nine sand dikes along a 3-km section of the Cache River and a 1-km section of Main Ditch near Karnack and a possible Quaternary-age fault along a 5-km section of the Post Creek Cutoff (Tuttle et al., 1996; Obermeier et al.,

1996; Munson et al., 1997). Weathering characteristics of the liquefaction features suggest that at least some of them are prehistoric in age, and radiocarbon dating of the host sediments indicate that the features formed during the past 5,300 years. The goals of this study were to search for additional liquefaction features and Quaternary age faults, to document and date the most significant features, and to use this information to estimate the timing and magnitudes of prehistoric earthquakes that have occurred in this region, and to identify the possible source areas for these events. During the project period from October 1, 2000, through September 20, 2001, we were particularly focused on completing our study along the lower Cache River.

Results

During reconnaissance along the lower Cache River, we found two possible fault zones exposed in the cutbank north of the town of Cache, Illinois. Each fault zone was partially excavated parallel to the existing northwest-facing cutbank of the river to reveal fault structure, faulted and unfaulted strata, cross-cutting relations and to provide a basis for preliminary interpretation.

Site Investigations

Cache River 106. At site CR106 along the lower Cache River, an area 4.25 m long and 5.5 m high was cleared and logged. The orientation of the cutbank wall at this location averaged N20°E, 35°NW. The main fault strikes northwest and juxtaposes Pliocene to early Pleistocene Mounds Gravel on the south and a sand, slit, clay unit on the north. The northern unit is an interbedded orange-buff-gray, sandy-silt to silty-clay layer containing sandy interbeds overlying a 1.15 m-thick layer of gray sandy-silt to sand layer containing thin, discontinuous sandy-silt, silty-sand and clay lenses and scattered lignite. The latter unit is interpreted to be a portion of the Cretaceous McNairy Formation, however, this stratigraphic designation is not definitive because the unit also is similar to descriptions of the Eocene Wilcox Formation. The lower gray zone of this unit displays leaf detritus along a few bedding planes at the surface of the outcrop. Bedding in this portion of the northern unit is tilted into the cutbank. The base of the Mounds Gravel is notably cemented to form large irregular to lens-shaped blocks that also are tilted into the cutbank.

Both units described above are overlain by an unfaulted, horizontal layer of reddish-pink to brownish-gray chert gravel in a fine sand and silt matrix. This gravel layer is similar to descriptions of reworked Mounds Gravel (Metropolis Gravel) of Nelson et al. (1997), in that the chert pebbles are brown and display patina, typical of the Mounds Gravel. The contact between the faulted and unfaulted zones is horizontal, continuous and approximately 1.6 to 2.15 m below the top of the cutbank. A small wedge of gravel was noted above the northern fault block adjacent to the fault contact; possibly a remnant colluvial wedge. Overlying this entire sequence are strata that consists from base to top of a red gravely silt layer, a buff silt layer, and a mottled dark brown silt containing discontinuous lenses of gray silt.

The fault that juxtaposes the Mounds Gravel and McNairy(?) is steeply-dipping and has an average orientation of N32°W, 42°SW. The northern block is cut by numerous small faults up to 2.6 m long in cross-sectional view. Two average fault orientations are common in this block: a northwest striking set that dips to the southwest and a northeast striking set

that dips to the northeast. It is possible that this structure is non-tectonic in origin, reflecting a paleoslump, or deep paleochannel filled with Mounds Gravel. However, the narrow character, apparent linear geometry, and possible similar structures down-river suggest that a tectonic origin also must be considered. This structure is similar to structures described previously in the region including two along the Post Creek Cutoff (Kolata et al., 1981; PCC9 of Tuttle et al., 1996, 1999; Nelson, 2000). If tectonic in origin, this feature may represent a fault bounding one side of a narrow graben or half-graben containing Mounds Gravel. Overall, the cutbank in this region has broken away from the main land surface and appears to have slid slightly toward the river. Further investigation would be necessary to establish how the main structure extends back into the cutbank, clarify the origin, and determine if the orientations of faults measured on the cutbank wall are representative.

Cache River 106. The second possible fault zone consists of a curviplanar surface that juxtaposes Paleocene Porter's Creek Clay and a thinly laminated to mottled, whitish-tan sandy silt to silt. The gray-brown silt at the base of the unit on the northwest side of the fault contains leaf detritus and resembles the northwestern unit described at CR106. The fault zone is variable in texture but on the average contains more silt and clay, and is massive rather than bedded. A thin layer of gravel is strung out within this zone. These units are overlain by a laterally continuous, unfaulted gray, silty zone containing clay nodules which in turn is overlain by 15 inches of reddish-yellow silt (Peoria Loess?) and 5 inches of modern soil. The fault-contact relationships and stratigraphic interpretations may be indicative of a paleo-slump event, or Cretaceous to Post-Cretaceous normal faulting episode. Additional work is required to establish the stratigraphic and structural context of this site and its relationship to CR105, as exposures visited to date suggest that several faults appear to have cut this region producing narrow graben-like features.

Summary

During this study, six sand dikes and two possible fault zones were found along the lower Cache River south of Sandusky, Illinois. Also, a liquefaction site near Karnack, found previously, and one of the possible fault zones near Sandusky were studied in detail. At least two generations of liquefaction features occur in the CRV. Both generations of sand dikes crosscut mottled silt of the Cahokia Formation thought to be late Wisconsin to Holocene in age (Willman and Frye, 1970). Radiocarbon dating indicates that sediments in which the liquefaction features occur are at least 5,300 years old. Therefore, both generations of the sand dikes formed during the past 5,300 years. In addition, dating suggests that the younger generation of liquefaction features near Karnack formed since 2890 B.C. and those near Sandusky formed since A.D. 1020. Unfortunately, no sand blows were found in the CRV, limiting our ability to further constrain the ages of the liquefaction features. Estimates of the timing, source area, and magnitude of causative earthquakes will have a high degree of uncertainty until the ages of liquefaction features are better known.

The deformation zones exposed in the lower Cache River require additional investigation to determine whether they are faults or slump features. If tectonic in origin, these deformation zones may represent Cretaceous to Post-Cretaceous normal faulting along a ~N40°E oriented structure and post-Pliocene faulting along a ~N30°W oriented structure. Our observations of deformation zones along the lower Cache River as well as the Post

Creek Cutoff (Tuttle et al., 1996, 1999; Nelson and McBride, 2000) suggest that several faults may cut this region producing narrow graben-like features.

Given the currently available information, the New Madrid seismic zone seems to be the most likely source of earthquakes that produced liquefaction features in the Cache River Valley. Nevertheless, faults associated with the Commerce geophysical lineament (Hoffman et al., 1996) or one of the northeast- or northwest-oriented deformation zones that crosses the region may be capable of producing earthquakes large enough (**M** 6) to induce liquefaction in the CRV. A careful search for liquefaction features in alluvial deposits in close proximity to the Commerce geophysical lineament might help to determine if associated faults have produced large earthquakes during the Holocene.

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Non-Technical Summary

J. Chester (TAMU) and M. Tuttle (M. Tuttle & Associates) performed a systematic search for and detailed study of earthquake-produced features in the Cache River Valley of southern Illinois to provide information about the timing and magnitudes of prehistoric earthquakes that occurred in this region, and to identify possible earthquake sources for these events. During this study, six sand dikes and two possible fault zones were found along the lower Cache River south of Sandusky, Illinois. The New Madrid seismic zone seems to be the most likely source of earthquakes (**M** 7-8) that produced liquefaction features in the Cache River Valley. Nevertheless, it can not be ruled out that faults associated with the Commerce geophysical lineament or one of the northeast- or northwest- oriented deformation zones that crosses the region might be capable of producing earthquakes large enough (**M** 6) to induce liquefaction in the Cache River Valley.

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